Version Showing Changes Made to Specification

Page 1, lines 9 through 11:

This is a continuation-in-part of U.S. [Patent Application] Serial No. 09/542,778 filed April 4, 2000, [in turn] now abandoned, which is a continuation-in-part of U.S. [Patent Application] Serial No. 09/466,701 filed December 17, 1999, now abandoned.

Page 17, line 22 through page 18, line 8:

As mentioned above, the preferred percentages of pores filled with reactant gas and water is dependent upon the size of the pores within the substrate layer and the pressure differential between the reactant gas streams **22**, **24** and the coolant stream. The percentage of pores containing liquid or reactant gas will be controlled by the respective coolant stream **26** and reactant gas **22**, **24** streams, wherein the reactant gas streams **22**, **24** will typically have a greater pressure than the coolant gas stream **26**. Specifically, because the pressure of the reactant gas streams **22**, **24** are typically equal to about ambient pressure, the pressure of the coolant stream **26** is less than ambient pressure. Moreover, the pressure differential between the coolant stream **26** and the reactant gas streams **22**, **24** will typically be in the range of about 0.5 psi to [5.0] 10.0 psi. It is even more preferable to maintain a pressure differential range of about 1.0 psi to 3.0 psi, and especially preferable to maintain a pressure differential range of about 2.0 psi to 2.5 psi.

Page 22, line 23 through page 23, line 2:

As shown in Fig. **4**, the anode water transport plate **84** is adjacent to the anode support plate **17**, and the cathode water [transparent] transport plate **86** is adjacent to the cathode support plate **19**. The anode and cathode water transport

plates **84**, **86** may be structured and/or oriented to cooperate with adjacent water transport plates **88**, **89** such that the passageways **96** and **98** simultaneously serve as the coolant stream for both the anode of one cell and cathode of the next cell.

Page 24, lines 12 through page 25, line 8:

Referring to Fig. **13**, there is shown an alternative embodiment of the anode and cathode water transport plates in a fuel cell **12a**. Specifically, the water transport plates **84'** [and], **86'**, **88'** and **89'** illustrated in Fig. **13** contain interdigitated gas passageways **110**, **112**, formed by dividing walls **93**, **93'**, rather than conventional passageways **92** as described in reference to Figs. **4** and **12**. Referring to Fig. **14**, there is shown a side elevation view of the cathode water transport plate **86'** illustrated in Fig. **13** that depicts the flow pattern of the oxidant reactant gas through interdigitated flow channels. The oxidant reactant gas enters the entrance of the entry passageway **110** and moves toward the closed ends **111**, which are obstructed. As the reactant gas moves toward the closed ends **111**, the pressure of the oxidant reactant gas stream forces the oxidant reactant gas into the cathode support plate **19**. After some oxidant is consumed in the cathode support plate **19**, the remaining or unused oxidant reactant gas enters the exit passageways **112** (as shown by the curved arrows in Fig. **14**) and migrates away from the closed ends **113** and is subsequently exhausted from the fuel cell. Because the oxidant reactant gas must pass through the cathode support plate **19** to enter the exit passageway **112**, the mass transfer of oxidant gas from the entry passageway **110** to the cathode support plate **19** increases. The reaction, in turn, increases the electrical performance of the fuel cell, which is described in further detail hereinafter. Although not shown, the interdigitated flow channel configuration for the passageways **110**, **112** in the anode water transport plate **84'** is similar to that for the cathode water transport plate **86'**.

Page 25, line 19 through page 26, line 15:

Referring to Fig. **15**, there is shown an alternative embodiment of the present invention that depicts a fuel cell **12b** having the interdigitated passageways **110**, **112** within the substrate layers **100'**, **102'** rather [then] than in the water transport plates **138**, **140**, thereby allowing the reactant gas streams to pass directly into and through the substrate layer in lieu of first entering the water transport plates. Specifically, the substrate layers **100'**, **102'** are oriented such that the passageways **110**, **112** are adjacent to flat porous water transport plates **138**, **140**, respectively. Because the interdigitated passageways **110**, **112** are within the substrate layers **100'**, **102'** rather then in the water transport plates **138**, **140**, the water transport plates **138**, **140**, are flat on the side adjacent the anode and cathode support layers **17'**, **19'**. The opposite side of the water transport plates **138**, **140**, however, have coolant passageways **134**. Additionally, the water transport plates **138**, **140** are still porous and allow water to pass therethrough. Although not shown, it is possible for the orientation of the substrate layers **100'**, **102'** to be reversed, such that the passageways **110**, **112** are adjacent the diffusion layers **104**, **106**. Additionally, although Fig. **15** illustrates interdigitated passageways **110**, **112** within the substrate layers **100'**, **102'**, it is possible that the flow pattern design of the passageways include conventional or serpentine passageways. Regardless of the configuration and/or material construction of the anode and cathode support plates within the fuel cell, the passageways within the water transport plates or substrate layers may be either conventional or interdigitated passageways.

Page 46, lines 7 through lines 12:

Fig. **19** illustrates the high current densities achievable with the fuel cell having the configuration designated by ▲, and interdigitated oxidant flow field. By limiting the stochiometry to below 2.50 (sometimes referred to as 250%), the parasitic power required for moving air through the cell, in an atmospheric PEM fuel

cell, is kept to a minimum. Fig. 19 specifically illustrates operation of the fuel cell at a maximum current density of at least 1.6 amps per square centimeter in response to a corresponding electrical load across said fuel cell, and operation of said fuel cell at current densities of less than 1.6 amps per square centimeter in response to related electrical loads across said fuel cell.

Version Showing Changes Made to Abstract

Abstract

Fuel Cell Having Interdigitated Flow Channels
and Water Transport Plates

[The present invention is a] A fuel cell power plant [that] includes a fuel cell having a membrane electrode assembly (MEA), which is disposed between [an] anode [support plate] and [a] cathode support plates.[, and] [p]Porous water transport plates [adjacent] or the [anode and cathode] support plates[. The porous water transport plates] have interdigitated flow channels for the reactant gas streams to pass [there]through and conventional flow channels for [a] coolant streams to pass [there]through. [The fuel cell power plant also has means for creating a pressure differential between the reactant gas streams and the coolant stream such that] [t]The pressure of the reactant gas streams is greater than the coolant stream[. Incorporating the interdigitated flow channels into] which, within the porous water transport plates [and operating the fuel cell at a pressure differential] allows the coolant water to saturate the water transport plates thereby forcing the reactant gases into the anode and cathode support plates. This, in turn, increases the mass transfer of such gases into the support plates, thereby increasing the electrical performance of the fuel cell. Current densities of about 1.6 amps per square [meter] centimeter are achieved with air stochiometries of not over 2.50.

Version Showing Changes Made to Claims

1. (Amended) A fuel cell power plant, comprising:

a fuel cell comprising an anode support plate including a porous substrate layer [having an interdigitated passageway for a fuel reactant gas stream to enter therein and exit therefrom], a cathode support plate including a porous substrate layer [having an interdigitated passageway for an oxidant gas stream to enter therein and exit therefrom], and a membrane electrode assembly disposed between said support plates, said membrane electrode assembly comprising a polymer electrolyte membrane disposed between two catalysts;

a first porous water transport plate adjacent to said cathode support plate, said first porous water transport plate having a passageway for a coolant stream to pass [there]through[, and an interdigitated passageway for an oxidant gas stream to enter therein and exit therefrom];

a second porous water transport plate adjacent to said anode support plate, said second porous water transport plate having a passageway for a coolant stream to pass [there]through[, and an interdigitated passageway for a fuel reactant stream to enter therein and exit therefrom];

either said cathode support plate or said first porous water transport plate having a passageway for an oxidant reactant gas stream to enter therein and exit therefrom, and either said anode support plate or said second water transport plate having a passageway for a fuel reactant gas stream to enter therein and exit therefrom, at least one of said reactant gas stream passageways being interdigitated;

means for creating a predetermined pressure differential between said oxidant gas stream and said coolant stream such that the pressure of said oxidant gas stream is greater than the pressure of said coolant stream; and

means for creating a predetermined pressure differential between said fuel reactant gas stream and said coolant stream such that the pressure of said fuel reactant gas stream is greater than the pressure of said coolant stream.

7. (Amended) [t]The fuel cell power plant of claim 6 wherein the pores within said hydrophilic substrate layer of said [cathode] one support plate [have] has a diameter such that when the pressure differential between said oxidant reactant gas stream and said coolant stream is equal to said predetermined pressure differential, a greater percentage of the pores contain oxidant gas rather than coolant.

14. (Amended) The fuel cell power plant of claim 5 wherein each said support plate further comprises a diffusion layer disposed between said substrate layer and said membrane electrode assembly.

17. (Amended) The fuel cell power plant of claim 5 wherein [both said support plates comprise a porous substrate layer and wherein] said fuel cell power plant further comprises [a] one said porous water transport plate adjacent to each said support plate.

19. (Amended) A method of operating a fuel cell power plant comprising:

(a) a fuel cell comprising an anode support plate and a cathode support plate and a membrane electrode assembly disposed between said anode and cathode support plates, said membrane electrode assembly comprising a polymer electrolyte membrane disposed between two catalysts, said support plates each comprising a substrate layer having pores therein;

(b) a porous cathode water transport plate adjacent to [one of] said cathode support plate[s,] either said cathode support plate or said porous cathode water transport plate having a passageway for an oxidant reactant gas stream to

enter therein and exit therefrom, and a porous anode water transport plate adjacent to said anode support plate, said anode support plate or said porous anode water transport plate having a passageway for a fuel reactant gas stream to enter therein and exit therefrom, each said porous water transport plate having a passageway for a coolant stream to pass [there]through, at least one of said reactant gas stream passageways being interdigitated [and an interdigitated passageway for a reactant gas stream to enter therein and exit therefrom]; and

(c) means for creating a predetermined pressure differential between said reactant gas streams and said coolant streams such that the pressure of said reactant gas streams is greater than the pressure of said coolant streams;

said method comprising:

flowing hydrogen-containing gas through said fuel reactant gas passageway [adjacent said anode support plate];

flowing air [at substantially atmospheric pressure] through said [interdigitated] oxidant reactant gas passageway;

controlling the flow rate of air to maintain an oxidant stochiometry of 250% or less;

operating said fuel cell at a maximum current density of at least 1.6 amps per square centimeter in response to [a] corresponding electrical loads across said fuel cell which require at least 1.6 amps per square centimeter; and

alternatively operating said fuel cell at current densities of less than 1.6 amps per square centimeter in response to related electrical loads across said fuel cell which require less than 1.6 amps per square centimeter.

20. (Amended) A method of operating a PEM fuel cell system comprising a plurality of fuel cells, each having a cathode support plate, an anode support plate, a membrane electrode assembly disposed between said support plates, [interdigitated] an oxidant flow channel[s] field on the cathode side of said membrane electrode assembly, and a fuel flow channel[s] field on the anode side of

said membrane electrode assembly, at least one of said fields having interdigitated flow channels, said method comprising:

flowing hydrogen-containing gas through said fuel flow channels;

flowing air [at substantially atmospheric pressure] through said oxidant flow channels;

controlling the flow rate of air to maintain an oxidant stochiometry of 250% or less;

operating said fuel cell at a maximum current density of at least 1.6 amps per square centimeter in response to [a] corresponding electrical loads across said fuel cell which require at least 1.6 amps per square centimeter; and

alternatively operating said fuel cell at current densities of less than 1.6 amps per square centimeter in response to related electrical loads across said fuel cell which require less than 1.6 amps per square centimeter.

Remarks

This Amendment is responsive to the Office Action of October 3, 2002, claims 1-21 remain for further consideration.

Priority

The cross-reference to related applications has been amended as suggested.

Information Disclosure Statement

Enclosed is a disclosure statement requesting references of the parent be utilized, with the listing that was submitted in the parent, and the appropriate fee.

Drawings

Only claim 1 included interdigitated flow channels in both the support plates and the water transport plates. This error was purely inadvertent and regretted. Claim 1 has been amended to refer to "either said cathode support plate or said first porous water transport plate...and either said anode support plate or said second water transport plate" having the reactant passageways. Thus, it is either one way or the other. The use of the "or" format is specifically permitted in MPEP 2173.05(h)II and 2173.05(h)I.

With respect to Fig. 12, the only thing in the application which would tend to support the allegation that "only that which is old is illustrated" in Fig. 12 is a brief description of Fig. 12 on page 11, wherein "conventional passageways"are referred to. Conventional, however, does not mean that all that is shown in Fig. 12 is old. There is a definition of "conventional passageways" on page 23: "The continuous, individual, straight, and substantially parallel passageways shall hereinafter be referred to as the conventional passageways." Thus, the word is referring to structure, not to knowledge of others in the prior art.

All of the reference signs referred to are present in the application by amendment to pages 24 and 25, except the sign 102' which has previously been present in page 25, at lines 21, 25 and 28 as well as page 26 at lines 6 and 9.

Therefore, withdrawal of the objection to the drawing is hereby respectfully requested.

Specification

The Abstract has been revised to eliminate reference to the invention and to conform it to 150 words.

Line 21 of page 25 has been corrected as required.

Claim 1 has been revised to be in the either/or format thus negating the possibility of claiming both at the same time. As amended, claim 1 calls for reactant passageways in either the transport plates or the support plates.

The range of "0.5 psi to 10 psi" has been added in page 18.

The limitation in claims 19 and 20 has been added by amendment to page 46.

Since all of the objections to the specification have been complied with, the objections have been overcome.

Claim Rejections - 112

Claim 1 has been amended to be in the alternative format. Claims 1 and 2, having no other rejection, are now allowable.

Claim 7 has been amended to refer to "said one support plate", which does have antecedence in claim 6.

Claim 14 has been amended to refer to "each said support plate".

Claim 17 has been amended to refer to "one said porous water transport plate", thus clearly referring to those of claim 5.

The limitations in claim 19 and 20 have been added to page 46. The nature of the load have been clarified in claims 19 and 20, as well as the fact that operation at at least 1.6 Asc and operation below 1.6 Asc are alternative.

Thus, all of the -112 rejections have been corrected by amendments, and should therefore now be withdrawn.

Claim Rejections - 103

Claims 3-21 are rejected as obvious over Wilson in view of Dufner et al (Dufner). Only claims 3, 5, 19 and 20 are independent claims; the patentability of the remaining claims depend on the patentability of the independent claims (MPEP 2143.03).

The first three paragraphs of the rejection are accurate and are not traversed. However, the paragraph beginning at the bottom of page 8 is not agreed with, and therefore, the conclusion of the rejection is traversed.

There are two embodiments in Wilson. The embodiment of Fig. 1C has the reactant gas flow passing through the macro porous support plate 44, either with or without channels. One would not therefore "have the porous water transport plates of Dufner which are also flow field plates adjacent the anode and cathode support plates" 44 of Fig. 1C of Wilson. If one were to do that, there would be two sets of flow fields. There certainly is no suggestion or motivation to do that. If one were to "have the porous water transport plates of Dufner which are also flow field plates adjacent the anode and cathode support plates" 24 of Fig. 1B in Wilson, then one would have the non-interdigitated water transport plates of Dufner. One would not have: -

Claim 3: "an interdigitated passageway for a reactant gas stream" (lines 7 and 8).

Claim 5: "an interdigitated passageway for a reactant gas stream" (lines 10 and 11);

Claim 19: "an interdigitated passageway for a reactant gas stream" (lines 11 and 12);

Claim 20: "interdigitated oxidant flow channels on the cathode side of said membrane electrode assembly" (lines 4 and 5).

Thus, the combination suggested in the rejection does not complete the claim language and therefore the rejection must fail. MPEP 2143 states: "Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations."

It is also alleged that it would be obvious to operate the coolant stream of Wilson "at a pressure differential of about 2-3 psi less than that of the reactant gas...." However, the only reference to pressure in Dufner is at column 8, line 19, which states "In some embodiments of the fuel cell...coolant liquid water...operates at a pressure differential of about 2-3 p.s.i. less than the reactant fluid 12....In such water-reactant pressure differential embodiments, it is therefore not necessary to have any discrete hydrophobic regions." Thus, it is stated by Dufner that the purpose of that is to eliminate the need for hydrophobic regions in the substrate layer. There is no other statement of usage of the pressure difference; no suggestion to use it for any other purpose than to eliminate the need for hydrophobic substrate layers. That also obviously refers to a fuel cell having all the characteristics of the fuel cells described in Dufner, which are considerably different than all of the characteristics described in Wilson. Wilson teaches in Fig. 4 and column 4, particularly lines 45 and 46, that the support layer should be formed "from a hydrophilic material." Having solved the problem, there is no need to solve it again. Therefore, there is no suggestion (MPEP 2145(j)(3)) to operate Wilson's water system at 2-3 psi below the reactant pressure, nor is there any motivation (MPEP 706.02(j), 2143, 2144) for operating Wilson's water system at 2-3 psi below the pressure of the reactants. Stated alternatively, because Wilson is using completely hydrophilic support plates, regardless of any pressure indications whatsoever, there is no teaching in Dufner that would suggest that Wilson needed

to remove hydrophobic regions (Wilson has none) by utilizing that pressure relationship. Certainly, Dufner cannot suggest the combination or provide motivation for modification of Wilson.

For the foregoing reasons, reconsideration and allowance of claims 3-21 over the references is hereby respectfully requested.

Conclusion

Should the foregoing not be persuasive, a telephone call is earnestly solicited.

Respectfully submitted,

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